WGClimate

The joint CEOS/CGMS Working Group on Climate

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Pilot Top-down Methane Emissions Estimates by Sector and Country to Support the Global Stocktakes

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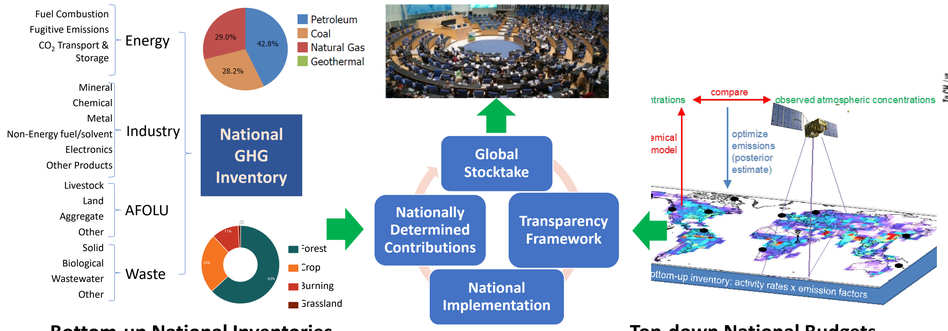
To support the 2023 Global Stocktake (GST), Parties to the Paris Agreement are compiling inventories of methane (CH_4) emissions and removals to assess progress toward their Nationally Determined Contributions (NDCs) to emission reductions.

These inventories are based on bottom-up methods that estimate annual emissions and removals of CH_4 from the sectors specified in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories

CH_4 emissions and removals can also be estimated from spatially- and temporally-resolved measurements of their concentrations using atmospheric inverse methods.

The Top-down atmospheric inventories derived from these fluxes are not as process-specific as bottom-up inventories, but complement those methods by providing a transparent, integrated constraint on fluxes from all processes on spatial scales spanning large power plants or urban areas to nations or the entire globe.

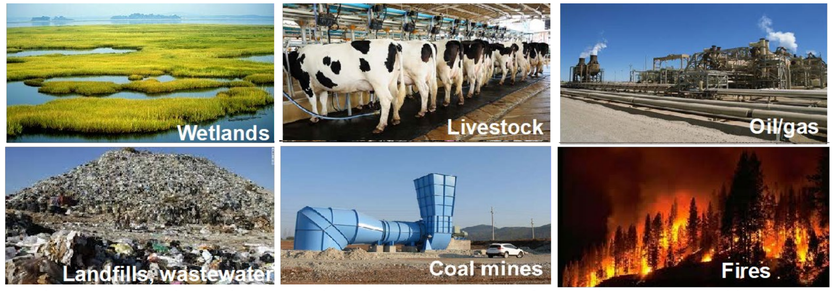
The primary objective of these pilot top-down GHG products is to start a conversation with stakeholders and users to establish the utility and best practices for combining bottom-up and top-down methods to enable a more complete and accurate Global Stocktake



Bottom-up National Inventories

Top-down National Budgets

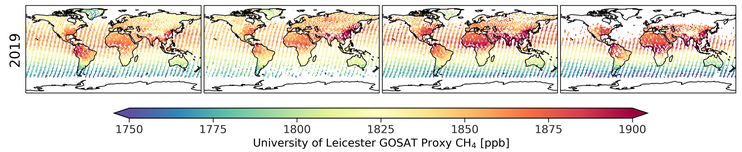
Processes Contributing to Methane (CH_4) Emissions



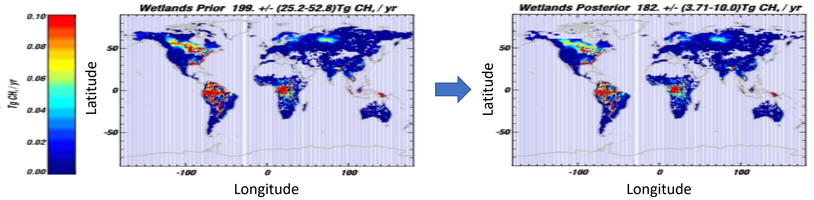
Methane is emitted into the atmosphere by a broad range of natural processes and human activities, many of which are difficult to measure with bottom-up inventories. Methane is removed primarily by atmospheric chemical reactions, which limit it atmospheric lifetime to 9.1 ± 0.9 years

Deriving Top-Down Methane (CH_4) Emissions

The NASA Carbon Monitoring System Flux (CMS-Flux) team analyzed remote sensing observations from Japan's Greenhouse gases Observing SATellite (GOSAT) to produce national-scale CH_4 emission budgets.

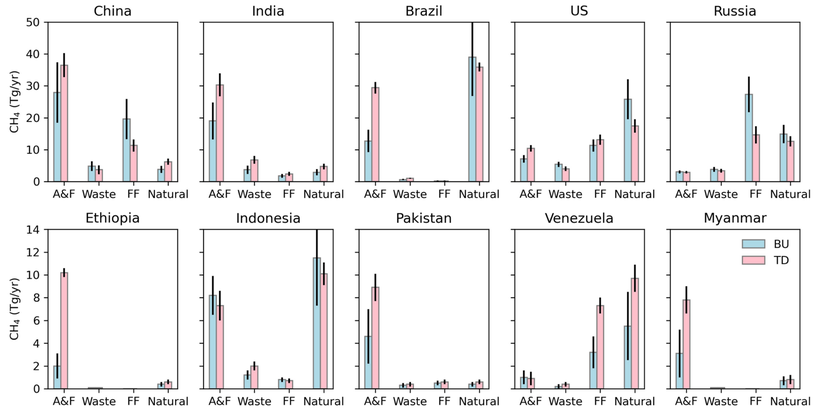


An analytic Bayesian inversion approach and the GEOS-Chem global chemistry transport model to quantify emissions and their uncertainties at a spatial resolution of 1° by 1° and then projected these to each country.



Maps of the prior (left) and posterior (right) CH_4 flux distributions for wetland emissions.

Country-level Methane emissions



Top-down (TD, pink) and bottom-up (BU, Blue) methane emissions by sector from the top 10 emitting countries are compared. The sectors shown include Agriculture and Fires (**A&F**), Waste, Fossil Fuels (**FF**), and **Natural** sources, such as wetlands and seeps.

Preliminary Conclusions

1) ***The existing observation and analysis system (GOSAT data + GEOS-Chem) can quantify total emissions for about 58 of the 242 countries.***

2) ***Both top-down and bottom up estimates indicate that the largest CH_4 emissions are from the agricultural sector (including waste and manure management), primarily livestock (enteric fermentation).***

3) ***Both top-down and bottom up estimates indicated that the top five emitting countries are responsible for about half (~170 Tg CH_4/yr) of the global anthropogenic CH_4 emission budget.***

4) ***It is challenging to reconcile recent reports of very large methane emissions from wetland plus aquatic sources (e.g. rivers, lakes, reservoirs, aquaculture) (~219-394 Tg CH_4/yr) with the top-down fluxes reported here***. A caveat to this conclusion is that rice farming and livestock emissions are indistinguishable from nearby, unspecified, aquatic emissions using remote sensing, highlighting a need for further research.

5) ***It is also challenging to reconcile these global top-down fossil emissions (Coal + Oil + Gas) based on remote sensing observation (80 to 100 Tg CH_4/ yr) with the much larger values inferred from in situ isotopic information (~160 +/- 20 Tg CH_4/yr) and prior inventories (e.g., ~97 +/- 23 to 128 +/- 15 Tg CH_4/yr).*** We find that fossil emissions tend to be spatially distinct from other emission sources and therefore are well resolved by remote sensing. At present time we cannot resolve this discrepancy between remote sensing estimates and these other approaches.

6) ***The sum of Agriculture, waste emissions, and fire emissions is 276 +/- 26 Tg CH_4/yr, larger than the prior emissions of 197 +/- 46 Tg CH_4/yr.*** These results are larger than but consistent (within reported uncertainties) with previous estimates of ~242 Tg CH_4/yr based on remote sensing or in situ data.

Caveat: Because we cannot easily quantify transport model error, these estimates should be treated cautiously and as a starting point for future investigations

For more information, see http://ceos.org/gst